time with regard to various types of metallized leads according to the invention;

Fig. 6 shows evaluation results of wetting force with regard to various types of metallized leads according to the invention;

Fig. 7 shows evaluation results of fillet strength in the case where there is formed a copper layer according to the invention;

Fig. 8 shows evaluation results of flat portion strength in the case where there is formed a copper layer according to the invention;

Fig. 9 shows an observation result of an interface region of a solder and a lead of an Fe-Ni alloy (i.e. 42 alloy) on which an Sn-10Pb alloy plating is provided according to the prior art, wherein (a) is a cross-sectional view of the interface region, and (b) are fractured surfaces at the lead side and the solder side, respectively;

Fig. 10 shows an observation result of an interface region of a solder and a lead of an Fe-Ni alloy (i.e. 42 alloy) on which an Sn-4Bi alloy plating is provided according to the invention, wherein (a) is a cross-sectional view of the interface region, and (b) are fractured surfaces at the lead side and the solder side, respectively; and

Fig. 11 shows an observation result of an interface region of a solder and a lead of an Fe-Ni alloy (i.e. 42 alloy) of the invention on which an

under copper layer and an upper Sn-4Bi alloy plating is provided according to the invention, wherein (a) is a cross-sectional view of the interface region, and (b) are fractured surfaces at the lead side and the solder side, respectively.

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, a description of embodiments according to the invention will be provided.

One embodiment of the invention is an electronic article, comprising a first and a second electrodes both of which are bonded with each other by means of a lead-free solder having low toxicity, the first electrode being a QFP lead, a TSOP lead or the like in an electronic device such as a semiconductor device (e.g. LSI), for example, and the second electrode being on a circuit board.

Another embodiment of the invention is a bonded structure comprising a first and a second electrodes both of which are bonded with each other by means of a lead-free solder having low toxicity.

The lead-free solder having low toxicity can be of an Sn-Ag-Bi alloy. With utilization of the Sn-Ag-Bi alloy, it is required to obtain a bonding interface which is stable with respect to a change in process of time and has a bonding strength high enough to withstand stress generated in solder-bonded portions due to a difference in thermal expansion coefficient between an electronic device and a circuit board, a

work of dividing the board after soldering, warping of the board during the probing test, handling and so on. It is also required to obtain an enough bonding strength with utilization of the lead-free Sn-Ag-Bi alloy solder by forming a sufficient fillet shape while ensuring enough wettability at 220-240°C, which is a suitable soldering temperature with respect to heat resistance of circuit boards and electronic devices. If the solder has inferior wettability, a sufficient fillet shape can not be obtained resulting in that an enough bonding strength is not obtained or a more active flux is required leading to an adverse influence on insulation resistance. Furthermore, it is also necessary to ensure resistance to formation of whiskers, etc. because short-circuit occurs between electrodes if whiskers are generated and grow on the electrode surface treated by plating, etc.

As shown in Figs. 1 and 2, an Sn-Bi layer 2 is formed on the surface of an electrode 1 of a lead to obtain enough bonding strength as the electrode structure of the invention. Next, a selection of an electrode structure of the invention will be described. Such selection was made by evaluating mainly bonding strength, wettability and resistance to occurrence whiskers based on the above requirements.

First, the result of an examination of the bonding strength obtained between an Sn-Ag-Bi alloy solder and various kinds of electrode materials are